STANDARD METAL POLE FOUNDATIONS

By Scott Hidden, P.E., Soils and Foundations Project Engineer
Soils and Foundation Design Section
Geotechnical Engineering Unit

How did we get to where we are?

- Signals and Geometrics Section wanted to "standardize" metal pole foundation design.
- Contacted Soils and Foundation Design and Soils wrote new specification entitled "DRILLED PIER FOUNDATIONS FOR METAL TRAFFIC SIGNAL POLES"
- Due to variability and unknowns associated with the "ground", elected to design standard foundations based upon site specific data, in other words, soil tests.

Advantages of Soil Tests

- Design is based upon site specific data - DEFENDABLE!
- Foundations should be smaller and less conservative.
- Finds problems before construction such as shallow rock and collapsing soils.
- Gives Contractor information to assist in foundation installation.
- Provides information about underground utilities.

Disadvantages of Soil Tests

- Costs? (Maybe)
- Time for testing and administration.
- Testing can not be done until grading is complete.
- Specifications include requirements to ensure that design assumptions are met.

  $\Rightarrow$ Closer inspection is required.

  For example, design is not for steep sloping ground.
- Different than “what we have always done”. Change! - Who moved my cheese?

The Handwriting on the Wall

ATV Drill Rig

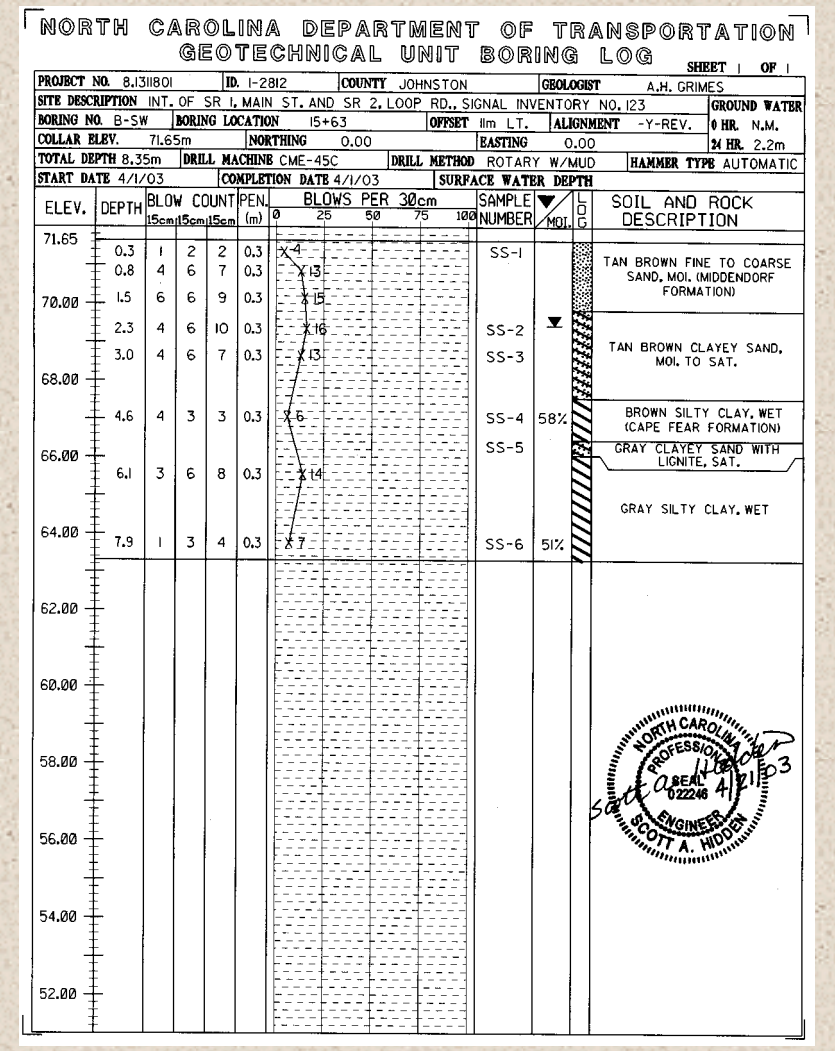
Standard Penetration Test (SPT)

- ASTM D 1586 - 99, 140 lb. Hammer, 30” Drop, 3-6” Increments
- Sum of blows for last two increments (12”) is called “N-value” or “blow count”.
- High N-value $\Rightarrow$ Dense, Stiff Soil
  Low N-value $\Rightarrow$ Loose, Soft Soil
- Sample can be retrieved from “split spoon” for classifying soil type.
- Very Common Empirical Test

Manual and Automatic Hammers

Split Spoon with Soil Sample

Example Soil Test Log and Selection Form



NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL UNIT BORING LOG

SHEET 1 OF 1

PROJECT NO. 8.1311801	ID. I-2812	COUNTY JOHNSTON	GEOLOGIST A.H. GRIMES
SITE DESCRIPTION INT. OF SR 1, MAIN ST. AND SR 2, LOOP RD., SIGNAL INVENTORY NO. 123			GROUND WATER 0 HR. N.M. 24 HR. 2.2m
BORING NO. B-SW	BORING LOCATION 15+63	OFFSET 11m LT.	ALIGNMENT -Y-REV.
COLLAR ELEV. 71.65m	NORTHING 0.00	EASTING 0.00	
TOTAL DEPTH 8.35m	DRILL MACHINE CME-45C	DRILL METHOD ROTARY W/MUD	HAMMER TYPE AUTOMATIC
START DATE 4/1/03	COMPLETION DATE 4/1/03	SURFACE WATER DEPTH	

ELEV.	DEPTH	BLOW COUNT 15cm	15cm	15cm	PEN. (m)	BLOWS PER 30cm (0 25 50 75 100)	SAMPLE NUMBER	MOI.	LOG	SOIL AND ROCK DESCRIPTION
71.65	0.3	1	2	2	0.3	X 4	SS-1			TAN BROWN FINE TO COARSE SAND, MOI. (MIDDENDORF FORMATION)
	0.8	4	6	7	0.3	X 13				
70.00	1.5	6	6	9	0.3	X 15				
	2.3	4	6	10	0.3	X 16	SS-2	▼		TAN BROWN CLAYEY SAND, MOI. TO SAT.
	3.0	4	6	7	0.3	X 13	SS-3			
68.00										
	4.6	4	3	3	0.3	X 6	SS-4	58%		BROWN SILTY CLAY, WET (CAPE FEAR FORMATION)
66.00							SS-5			GRAY CLAYEY SAND WITH LIGNITE, SAT.
	6.1	3	6	8	0.3	X 14				GRAY SILTY CLAY, WET
64.00	7.9	1	3	4	0.3	X 7	SS-6	51%		
62.00										
60.00										
58.00										
56.00										
54.00										
52.00										

NORTH CAROLINA PROFESSIONAL SEAL 022246 ENGINEER SCOTT A. HIDDEN
Scott A. Hidden 4/21/03

METAL POLE STANDARD FOUNDATION SELECTION FORM

SIGNAL INVENTORY NO.: 123 DATE: 4/21/03

INTERSECTION OF: SR 1, MAIN ST. AND SR 2, LOOP RD.

BORING LABEL: B-SW COUNTY: JOHNSTON

RESIDENT OR DIVISION ENGINEER: M. McKEEL, P.E.

CONTRACTOR NAME: C. C. MANGUM

BORING INFORMATION:

SPT DEPTH	1 ft (0.3 m)	2.5 ft (0.8 m)	5 ft (1.5 m)	7.5 ft (2.3 m)	10 ft (3.0 m)	15 ft (4.6 m)	20 ft (6.1 m)	26 ft (7.9 m)
N-VALUE MIN = 0 MAX = 50	4	13	15	16	13	6	14	7

N_{AVG} = (N@1' + N@2.5' +..... N@Deepest Boring Depth*) / Total Number of N-values = 11

$Y = (N@1')^2 + (N@2.5')^2 + \ldots\ldots (N@Deepest\ Boring\ Depth*)^2$ = 1116

$Z = (N@1' + N@2.5' + \ldots\ldots N@Deepest\ Boring\ Depth*)$ = 88

*Note: Do not include the N-value at the deepest boring depth if the boring is discontinued because one of the following occurs:

- A total of 100 blows have been applied in any 2 consecutive 6-in. (0.15-m) intervals.
- A total of 50 blows have been applied with < 3-in. (.08-m) penetration.

$$N_{STD\ DEV} = \left\{ \frac{(\text{Total Number of N-values} \times Y) - Z^2}{(\text{Total Number of N-values}) \times (\text{Total Number of N-values} - 1)} \right\}^{0.5} = 5$$

Design N-value equals lesser of the following two conditions:

$N_{AVG} - (N_{STD\ DEV} \times 0.45)$ OR $\frac{(N@1' + N@2.5' + N@5' + N@7.5')}{4}$ = 9

9 12

IS **Design N-value** LESS THAN 4? Yes _____ No ✓
If yes, standard drilled pier foundation from Foundation Selection Table on plans can not be used.

DESCRIPTION OF SOIL: SAND

DRILLED PIER LENGTH (L): 18.5 (ft) or m (circle) **From Foundation Selection Table on Plans**

DEPTH OF BORING: 26 (ft) or m (circle)

IS DRILLED PIER LENGTH, L, GREATER THAN DEPTH OF BORING? Yes _____ No ✓
If yes, standard drilled pier foundation from Foundation Selection Table on plans can not be used.

CONTRACTOR REPRESENTATIVE SIGNATURE: J. Smith

DIVISION REPRESENTATIVE SIGNATURE: M. McKeel

Not Applicable Everywhere !

Foundation Selection Table from Plans

PROJECT REFERENCE NO. | SHEET NO. Sig. dwg.SP2

23. THE FOUNDATION SIZE FOR POLES IN THESE METAL POLE STANDARDS IS DETERMINED BY CONDUCTING A SUBSURFACE SOIL INVESTIGATION. FOR DETAILS OF THE SUBSURFACE INVESTIGATION, AND PROPER SELECTION/DETERMINATION OF THE METAL POLE FOUNDATIONS, REFER TO AND COMPLY WITH THE "METAL POLE STANDARD FOUNDATIONS" SPECIAL PROVISION WHICH IS TO BE CONSIDERED AN INTEGRAL PART OF THESE METAL POLE STANDARDS.

24. STRAIN POLE FOUNDATIONS DEPTHS HAVE BEEN PRE-DESIGNED USING THE CHART SHOWN BELOW. TO DETERMINE THE CORRECT DEPTH OF EACH FOUNDATION:

a.- USING THE STATEWIDE COUNTY WIND ZONE CHART ON DRAWING SP3 (LOAD CASE AND DESIGN DETAILS), MAKE SURE YOU HAVE THE APPROPRIATE WIND ZONE SELECTED.
b.- SELECT THE SOIL TYPE THAT BEST DESCRIBES THE SOIL CHARACTERISTICS (EITHER CLAY OR SAND)
c.- PERFORM A STANDARD PENETRATION TEST AT EACH PROPOSED FOUNDATION SITE TO DETERMINE "N" VALUE. (NUMBER OF BLOWS PER FOOT FROM STANDARD PENETRATION TEST).
d.- GET THE APPROPRIATE POLE CASE LOAD NUMBER FROM THE PLANS OR FROM THE DIVISION TRAFFIC ENGINEER.
e.- USING THE PREVIOUSLY DETERMINED SOIL TYPE AND "N" VALUE, SELECT THE APPROPRIATE COLUMN IN THE CHART. SELECT THE APPROPRIATE LINE THAT THE POLE LOAD CASE IS SHOWN ON IN THE CHART. THE CORRECT DEPTH OF THE FOUNDATION IS THE VALUE THAT IS SHOWN WHERE THE COLUMN AND THE LINE INTERSECT.
f.- FILL OUT AND SUBMIT FOR APPROVAL TO THE DIVISION A "STANDARD FOUNDATION SELECTION FORM" FOR EACH PROPOSED FOUNDATION LOCATION.

FOUNDATION SELECTION TABLE

42" Diameter Drilled Pier Length (L) - Feet

LOAD CASE	WIND ZONE 3 - SOIL TYPES						
	Clay				Sand		
	Medium Design N-Value 4-8	Stiff Design N-Value 9-15	Very Stiff Design N-Value 16-30	Hard Design N-Value >30	Loose Design N-Value 4-10	Medium Design N-Value 11-30	Dense Design N-Value >30
S26L2	18.5	13.0	10.5	9.0	17.5	15.0	13.5
S30L2	19.5	13.5	11.0	9.0	18.0	15.5	14.0
S36L2	20.0	14.0	11.5	9.5	18.5	16.0	14.5
S30H2	23.0	15.5	12.5	10.0	20.5	17.5	16.0
S35H2	24.0	16.0	13.0	10.5	21.0	18.0	16.5

CONCRETE VOLUME (cubic yards)=.356xL

25. A "STANDARD FOUNDATION SELECTION FORM" FOR EACH PROPOSED FOUNDATION IS REQUIRED TO BE SUBMITTED AND APPROVED PRIOR TO ANY DRILLING IN THE FIELD. THIS FORM AS WELL AS THE STANDARD FOUNDATION SPECIAL PROVISIONS CAN BE OBTAINED AT THE FOLLOWING WEBSITE:

http://www.doh.dot.state.nc.us/preconstruct/highway/dsn_srvc/soils/form/default.htm

26. COMPLY WITH THE PROVISIONS OF SECTION 1742 OF THE STANDARD SPECIFICATIONS FOR INSTALLATION.
27. REFER TO STANDARD DRAWING 1742.01 FOR FOR FOUNDATION INSTALLATION DETAILS.
28. REINFORCING STEEL SHALL BE DEFORMED AND CONFORM TO ASTM A615 GRADE 60. TIES MAY BE DEFORMED OR PLAIN.
29. CIRCULAR TIE REINFORCING RINGS MAY BE VERTICALLY ADJUSTED BY +/- 3" AT A DEPTH BETWEEN 2'-0" AND 3'-0" TO FACILITATE THE INSTALLATION OF ELECTRICAL CONDUIT ENTERING IN THE CAGE.
30. THE CONCRETE SHALL BE DRILL PIER CONCRETE WITH A MINIMUM COMPRESSIVE STRENGTH OF 4500 PSI AT 28 DAYS IN ACCORDANCE WITH SECTION 1000 OF THE NORTH CAROLINA STANDARD SPECIFICATIONS. FOR DETAILS, SEE SPECIAL PROVISIONS.
31. THE TRAFFIC SIGNAL SUPPORT STRUCTURE SHALL NOT BE ERECTED BEFORE THE CONCRETE IN THE FOUNDATION HAS ATTAINED A MINIMUM COMPRESSIVE STRENGTH OF 3000 PSI.
32. NON-SHRINK GROUT SHALL BE A MIX CONSISTING OF 1 PART CEMENT, 3 PARTS SAND BY WEIGHT, AND 2 GRAMS OF ALUMINUM POWDER PER 94 LBS. OF CEMENT USED. WATER SHALL BE LIMITED TO THAT AMOUNT REQUIRED TO PRODUCE A WORKABLE MIX. PROVIDE SMALL PIPE TO DRAIN WATER PER STANDARD SPECIFICATIONS.
33. THE TOP OF EACH FOUNDATION SHALL BE PERMANENTLY MARKED (WITH STAMP OR EMBEDDED PLATE) TO IDENTIFY THE TYPE OR DEPTH OF THE FOUNDATION.
34. FOR OTHER DETAILS REGARDING CONSTRUCTION OF CONCRETE FOUNDATION, SEE PROJECT SPECIAL PROVISIONS.

35. COMPLY WITH THE PROVISIONS OF SECTION 1072 & 1742 OF THE STANDARD SPECIFICATIONS FOR INSTALLATION.
36. REFER TO STANDARD DRAWING 1742.01 FOR FOR POLE AND HARDWARE INSTALLATION DETAILS.
37. SIGNAL HEADS CAN BE PLACED ANYWHERE ALONG THE SPANWIRE. THE MOST CRITICAL LOCATIONS ARE SHOWN IN THE TYPICAL INTERSECTION LOADING CASE. FOR DESIGN PURPOSES, USE 4% SAG FOR THE SPANWIRE.
38. WHEN ATTACHING POLE TO FOUNDATION, THE DISTANCE BETWEEN THE BOTTOM OF THE LEVELING NUT TO THE TOP OF THE CONCRETE FOUNDATION SHOULD NOT BE GREATER THEN ONE ANCHOR NUT HEIGHT. THE TOP OF EACH ANCHOR BOLT SHOULD NOT EXTEND MORE THAN ONE ANCHOR NUT HEIGHT ABOVE TOP NUT TO FACILITATE THE INSTALLATION OF A THREADED NUT COVER.
39. STRAP ALL SIGNAL CABLES TO THE SIDE OF THE POLE WHEN THE DISTANCE BETWEEN THE SPANWIRE ATTACHMENT CLAMP ON THE POLE AND THE WEATHER HEADS EXCEEDS 36". USE ¾" STAINLESS STEEL STRAPS TO LASH WIRE TO THE POLE. SEE DRAWING SP4 (POLE FABRICATION DETAILS) OF THESE STANDARDS FOR GRAPHIC DETAILS.
40. FOR OTHER DETAILS REGARDING METAL POLE INSTALLATION, SEE PROJECT SPECIAL PROVISIONS.

WIND ZONE 3 (110 MPH)

METAL POLE STANDARD NOTES

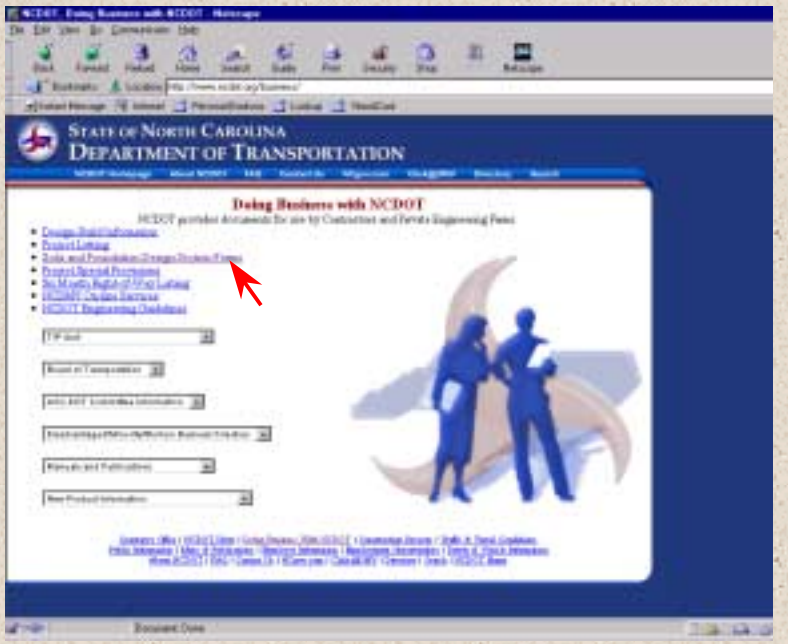
PLAN DATE: SEPTEMBER 2002 REVIEWED BY: R. E. HULLIHAN
PREPARED BY: C. F. ANDREWS REVIEWED BY: B. C. SARKAR
REVISIONS | INIT. | DATE

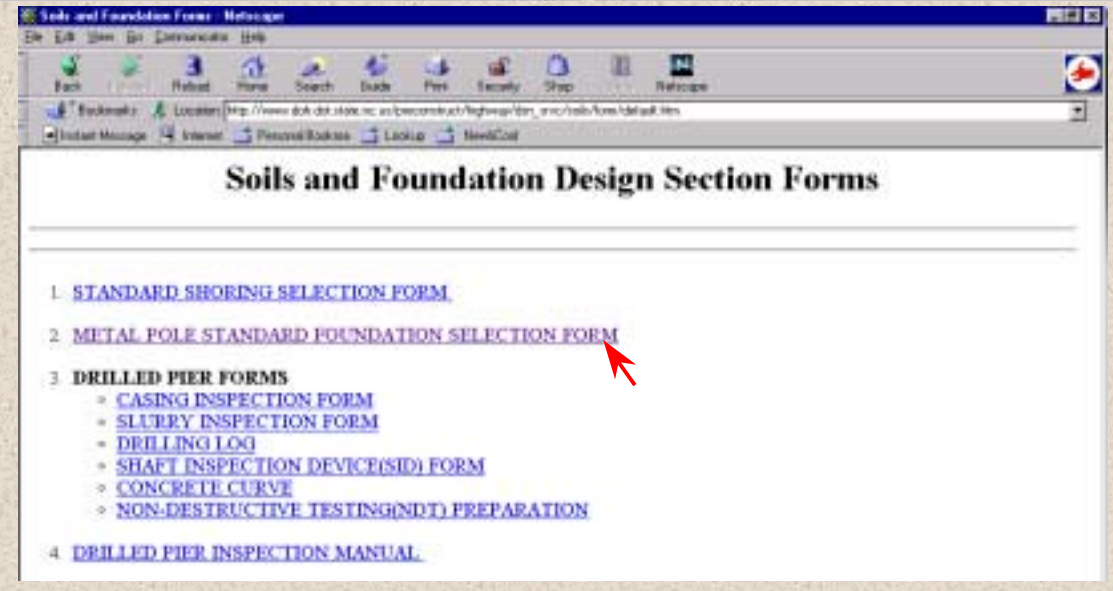
SCALE: NONE

SEAL 029094 ENGINEER DEBESH C. SARKAR NORTH CAROLINA

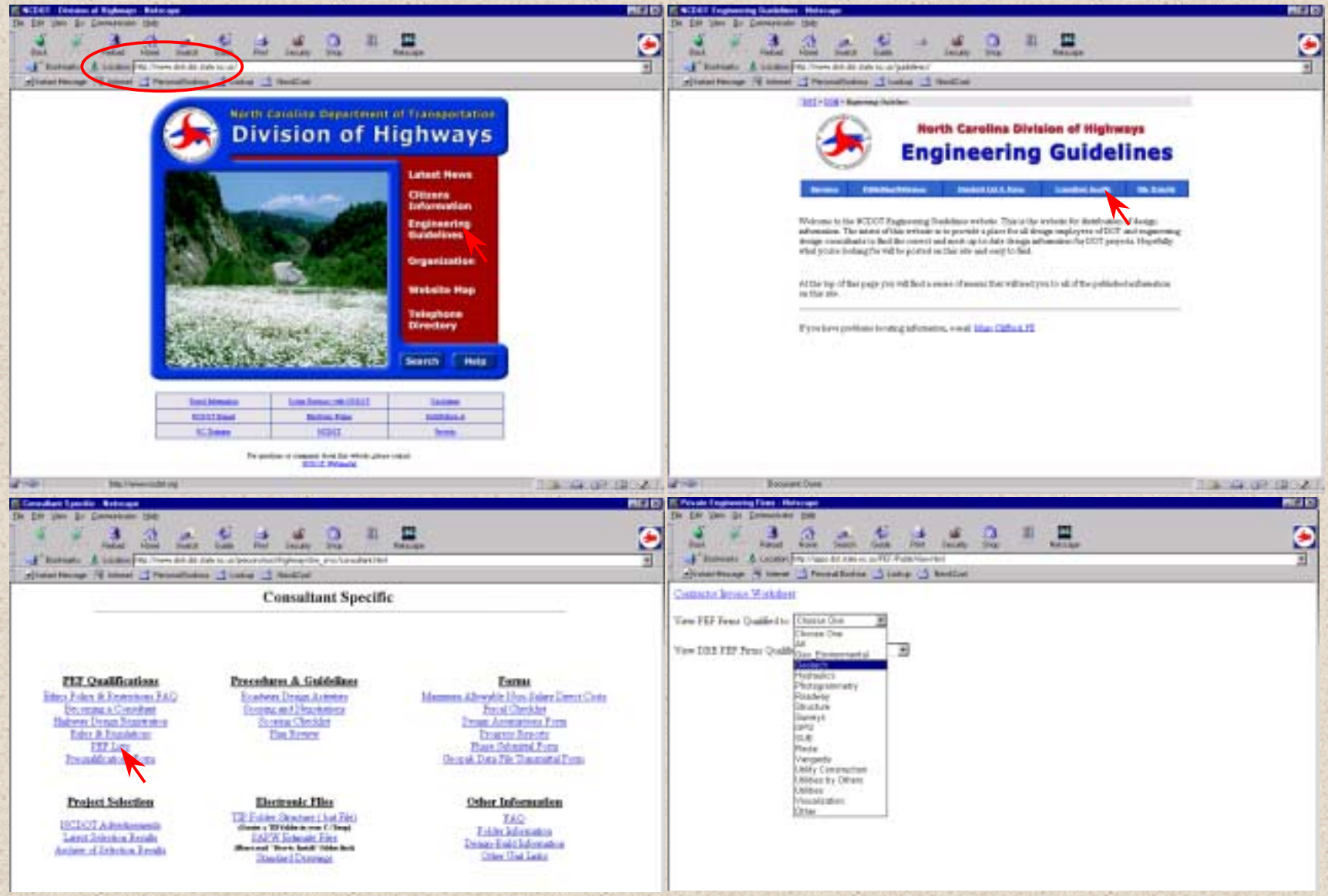
2.14.03

Where can I find the foundation selection form?





Where can I find a list of firms to perform soil tests?



Section 1.3, “Drilled Pier Construction”

- Specifications are written based upon criteria for horizontal and rotational movement (1 inch and 1 degree).
- DRILLED PIERS MUST BE CAST AGAINST UNDISTURBED SOIL!
- Pared Down Drilled Piers Special Provision used for Bridge Construction
- Two Pay Items:
  - Soil Test……..……Each
  - Drilled Pier Foundation (____-inch (mm) diameter)……Linear Foot (Linear Meter)

Signal Contractors do not want to drill this!

And Divisions do not want to pay to drill this!

What does the new specification say?

- Requires steel casing when “unstable, caving or sloughing soils are anticipated or encountered”.
- “Provide one continuous piece of steel casing that is clean smooth non-corrugated watertight steel ….”.
- 1/4” Minimum Wall Thickness with Outside Diameter Equal to Specified Size of the Pier
- Casing is temporary (must be removed) except when Contractor elects to make it permanent at his own cost provided it is installed correctly and with an exception.

Steel Casing

Permanent Steel Casing and Mast Arms

"Any steel casing left in place will be considered permanent casing and must be installed before excavating or drilling such that the permanent casing is against undisturbed soil. Permanent steel casings are only allowed for strain poles and prohibited for mast arm poles. No additional compensation will be paid for permanent casing. If the Contractor chooses to use permanent steel casing, include all costs for permanent casing in the cost of the contract unit price bid for the "Drilled Pier Foundation" pay item."

Mast Arms

Plastic Bolsters and Spacer Wheels

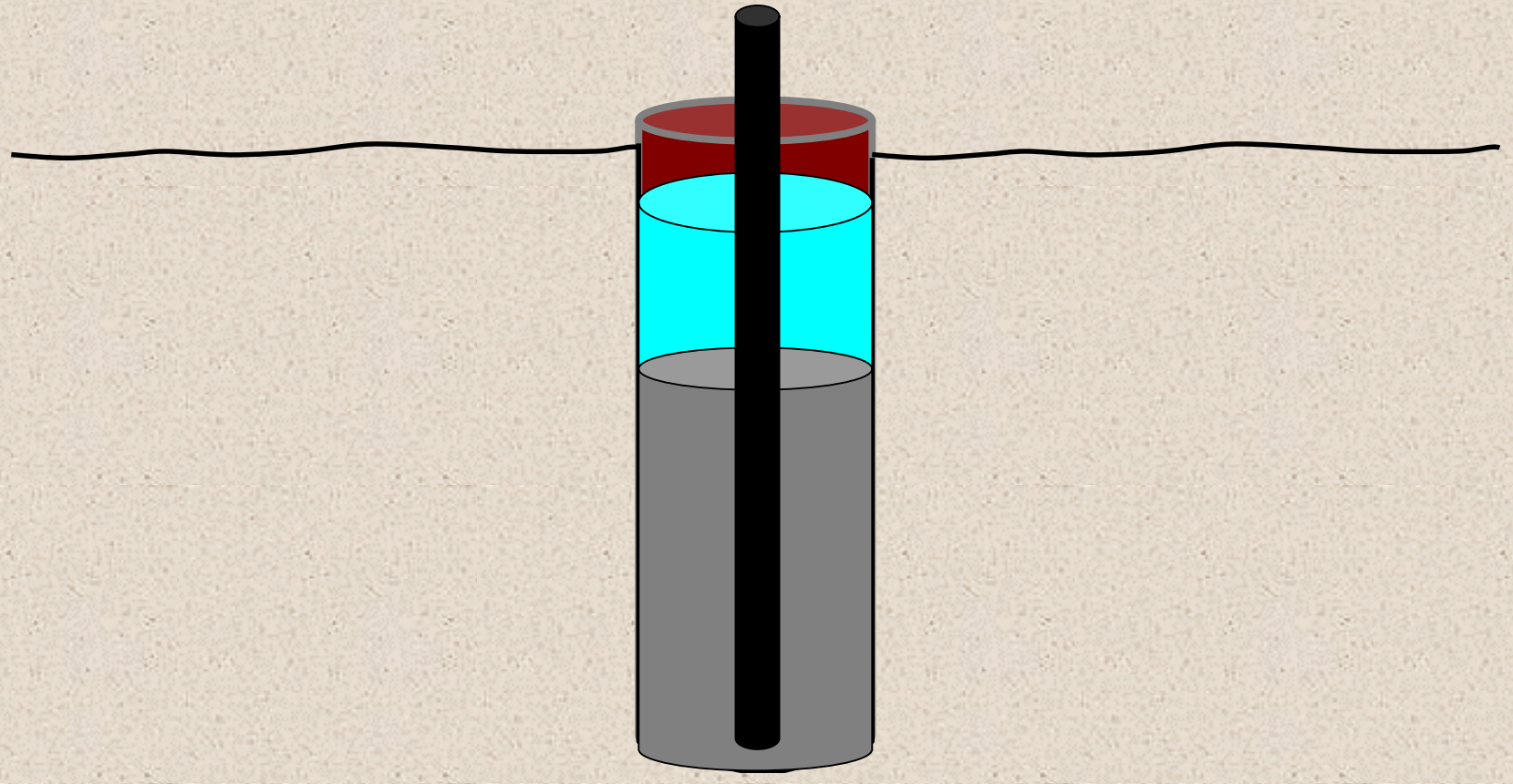
Drilled Pier Concrete

- “Designate the concrete as Drilled Pier Concrete with a minimum compressive strength of 4500 psi (31.0 MPa) at 28 days.”
- “Produce a workable mix so that vibrating or prodding is not required to consolidate the concrete. When placing the concrete, make certain the slump is between 5 and 7 inches (125 and 175 mm) for dry placement of concrete or 7 and 9 inches (175 and 225 mm) for wet placement of concrete.”

Concrete Placement

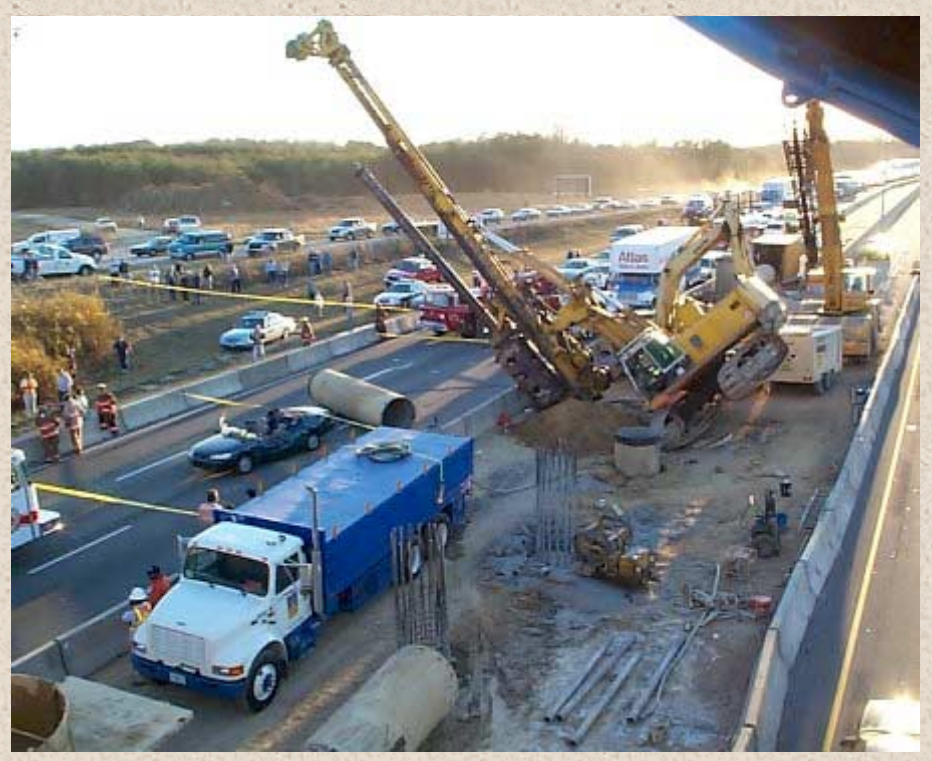
- What is a dry or wet pour?
- How do we determine the pour type?
  - Greater than 6” per half hour $\Rightarrow$ Wet
  - Less than 6” per half hour $\Rightarrow$ Dry
- “Do not dewater any drilled pier excavations unless the excavation is entirely cased down to tip.”
- DO NOT FORCE A DRY POUR!

Wet Pour Sequence



Result of Forced Dry Pour

Safety First!



ANY QUESTIONS?

"Hey, it's not my job."